Broadband Reflectarray Element for Dual Polarization Made of Orthogonal Sets of Parallel Dipoles

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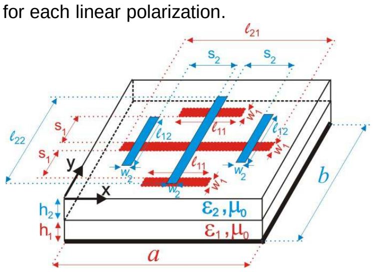
Abstract: A broadband reflectarray element is proposed for dual-polarization. The element consists of two orthogonal sets of three coplanar parallel dipoles. Each set of coplanar parallel dipoles is used for controlling the phase-shift for each polarization of the incident electric field. A home-made software based on the Method of Moments in the Spectral Domain (MoM-SD) has been used to compute the phase, losses and cross-polarization performance of the reflectarray element in a periodic environment. This software is a powerful numerical tool for the design of dual-polarization reflectarray antennas under the local periodicity assumption. The results obtained with the home-mode software have been compared with results provided by the commercial software CST®, and excellent agreement has been found. Also, significant CPU time savings can be achieved with our software by comparison with CST®. The dual-polarization element proposed in this paper has proven to show a broadband and low loss performance.

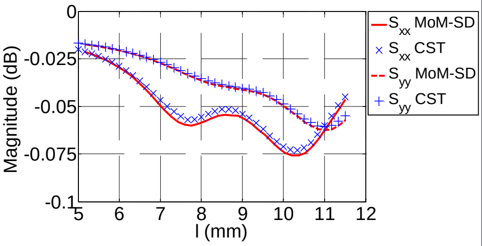
1. Introduction

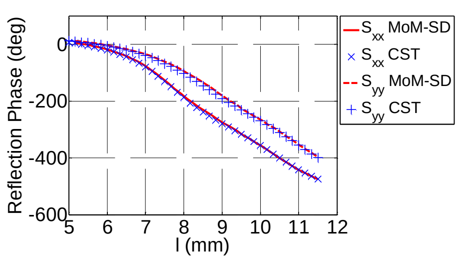
- In this work, we propose a broadband multi-resonant reflectarray element for dual polarization applications which contains two orthogonal sets of three coplanar parallel dipoles at two different metallization levels.
- Whereas one set of three coplanar parallel dipoles is used for controlling the phase-shift in one polarization, the orthogonal set controls the phase in the orthogonal polarization.
- This element keeps the advantages of some of the single layer multi-resonant reflectarray elements in terms of phase range and broadband, and adds additional features, such as low levels of cross-polarization and the flexibility of providing independent adjustment of the phase for each linear polarization.



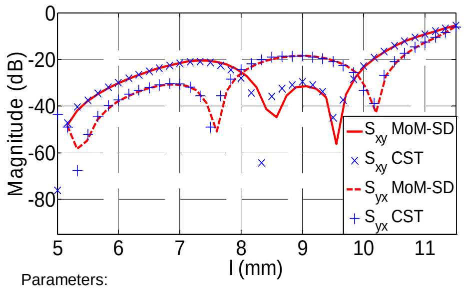
2. Characterization of the reflectarray element

- A home-made software based on the Method of Moments in the Spectral Domain has been implemented for the analysis of the reflectarray element under the local periodicity assumption.
- Validation of copolar reflection coefficients at normal incidence:





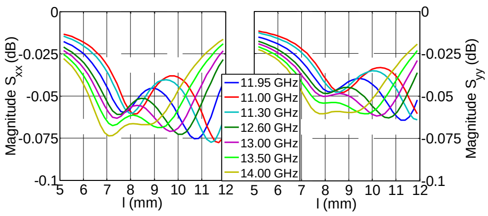
- Validation of crosspolar reflection coefficients at oblique incidence ($\theta = \phi = 25^o$):

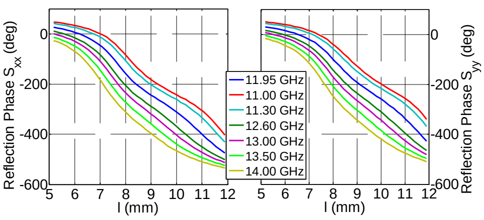


Parameters:

$a = b = 12$ mm; $l_{21} = l_{22} = l$; $l_{11} = l_{12} = 0.63l$; $s_1 = s_2 = 3.5$mm; $w_1 = w_2 = 0.5$ mm; $\varepsilon_{r1} = \varepsilon_{r2} = 2.17$; $\tan\delta_1 = \tan\delta_2 = 0.0009$; $h_1 = 3.175$ mm; $h_2 = 0.508$ mm.

- Copolar reflection coefficients at different frequencies for normal incidence.





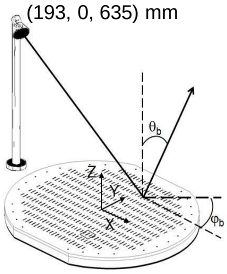
Parameters:

$a = b = 12$ mm; $l_{21} = l_{22} = l$; $l_{11} = l_{12} = 0.63l$; $s_1 = s_2 = 3.5$mm; $w_1 = w_2 = 0.5$ mm; $\varepsilon_{r1} = \varepsilon_{r2} = 2.17$; $\tan\delta_1 = \tan\delta_2 = 0.0009$; $h_1 = 3.175$ mm; $h_2 = 0.127$ mm.

3. Reflectarray prototype

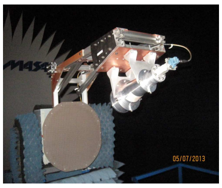
- A 40-cm reflectarray antenna has been designed to produce a focused beam in the direction θ_b= 16.9º and φ_b= 0º at the single frequency 11.95 GHz for both linear polarizations.
- The reflectarray consists of 861 elements arranged in a 33x33 grid with cell size 12mm x 12mm (diameter of 396 mm)

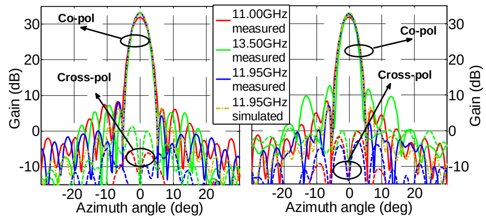
$(x, y, z)_{feed}$ = (193, 0, 635) mm

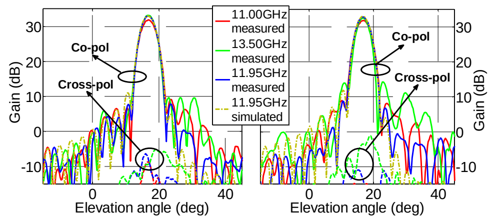


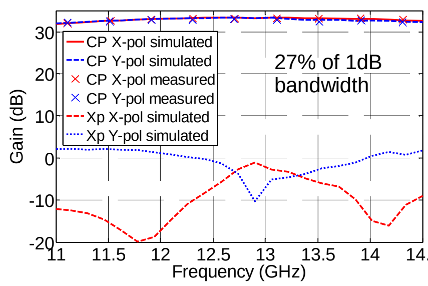
4. Measured patterns

- The antenna prototype has been measured in a compact-range anechoic chamber.









5. Conclusions

- The reflectarray element has shown a linear and smooth behavior of the phase curves and low losses (lower than 0.08 dB) in a wide interval of frequencies (from 11 GHz to 14 GHz). The flexibility provided by the independent adjustment of the phase for each polarization.
- A 40-cm focused beam reflectarray antenna has been designed, manufactured and tested. The results show a 27% antenna bandwidth for a gain variation of 1dB and cross-polar radiation at least 30dB below the copolar radiation.